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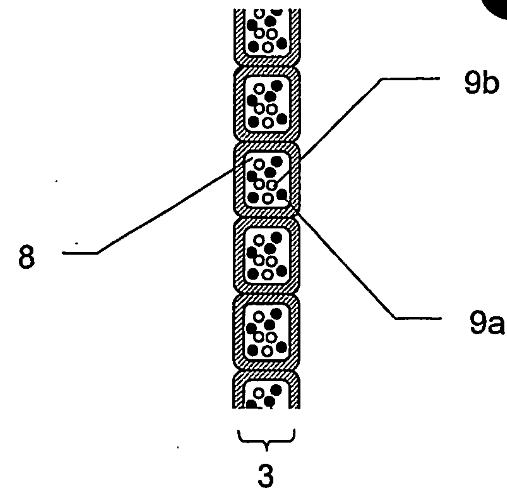

Fig. 1a

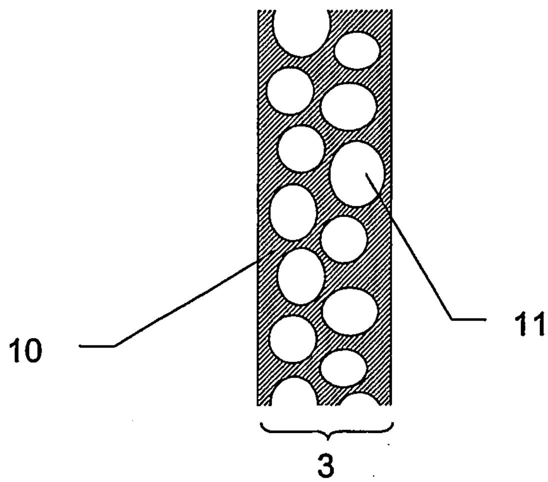

Fig. 1b

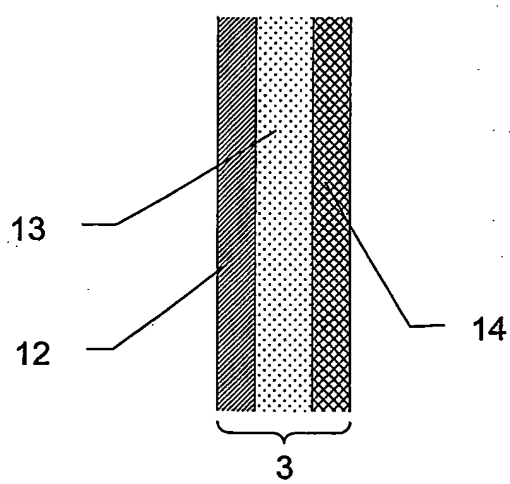

Fig. 1c

Claims

1. A passive indicator of voltage presence, in the form of a multilayer plate comprising two electrically conductive layers and an intermediate layer of a structure showing electrooptical properties, located between them, **characterised in that** the intermediate layer is a display element of the indicator, and the electrically conductive layers are electrodes of the display element and they are electrically connected with each other by means of a diode and one of the conductive layers is at least partially transparent.
2. Passive indicator according to claim 1, **characterised in that** the intermediate layer of the indicator is an electrophoretic structure.
3. Passive indicator according to claim 1, **characterised in that** the intermediate layer of the indicator is a liquid-crystal based electrooptical structure.
4. Passive indicator according to claim 1, **characterised in that** the intermediate layer of the indicator is an electrochromic structure.
5. A passive indicator of voltage presence, in the form of a multilayer plate comprising two electrically conductive layers and an intermediate layer of a structure showing electrooptical properties, located between them, **characterised in that** the intermediate layer is a display element of the indicator, and the electrically conductive layers are electrodes of the display element and they are electrically connected with each other by means of a diode and there is a dielectric layer located between the intermediate layer and one of the conductive layers, and one of the conductive layers is at least partially transparent.

6. Passive indicator according to claim 5, **characterised in that** the intermediate layer of the indicator is an electrophoretic structure.
7. Passive indicator according to claim 5, **characterised in that** the intermediate layer of the indicator is a liquid-crystal based electrooptical structure.
8. Passive indicator according to claim 5, **characterised in that** the intermediate layer of the indicator is an electrochromic structure.
9. A passive indicator of voltage presence, in the form of a multilayer plate comprising two electrically conductive layers and an intermediate layer of a structure showing electrooptical properties, located between them, **characterised in that** the intermediate layer is a display element of the indicator, and the electrically conductive layers are electrodes of the display element and they are electrically connected with each other by means of a diode, and between the intermediate layer and one of the conductive layers there is located a dielectric layer , which is separated from the intermediate layer by an additional electrically conductive layer, and one of the conductive layers is at least partially transparent.
10. Passive indicator according to claim 9, **characterised in that** the intermediate layer of the indicator is an electrophoretic structure.
11. Passive indicator according to claim 9, **characterised in that** the intermediate layer of the indicator is a liquid-crystal based electrooptical structure.
12. Passive indicator according to claim 9, **characterised in that** the intermediate layer of the indicator is an electrochromic structure.
13. A passive indicator of voltage presence, in the form of a multilayer plate comprising two electrically conductive layers and an intermediate layer of a structure showing electrooptical properties, located between them, **characterised in that** the intermediate layer is a display element of the indicator, and the electrically conductive layers are electrodes of the display element and at least one of the electrically conductive layers is divided into smaller conductive surfaces, separated from each other and being not in contact with one another, which adhere to the intermediate layer and are electrically connected with the other electrically conductive layer, or with the individual conducting surfaces that other electrically conductive layer is

divided into, by means of diodes whose electrodes are oriented in opposite directions with respect to the connected electrically conductive layers or their conductive surfaces, and at least one of the electrically conductive layers is at least partially transparent.

14. Passive indicator according to claim 13, **characterised in that** the intermediate layer of the indicator is an electrophoretic structure.

15. Passive indicator according to claim 13, **characterised in that** the intermediate layer of the indicator is a liquid-crystal based electrooptical structure.

16. Passive indicator according to claim 13, **characterised in that** the intermediate layer of the indicator is an electrochromic structure.

conductive layers 2 and 4, which causes an increase of the voltage generated between those electrodes by the tested electric field, and thus an increase in the indicator sensitivity. In order to decrease the real part of the impedance of the layer 15 and to increase the D.C. voltage component generated in the intermediate layer 3, the layer 15 can also be made of dielectric material of weak electric conductivity, for instance, of carbon-black doped polymer. Alternatively, the dielectric layer 15 can be placed between the intermediate layer 3 and the conductive layer 2, which is not shown in the drawing. In both cases, the conductive layers 2 and 4 are connected with one another by means of the diode 5 as in the earlier described embodiments. In this variant embodiment of the invention the intermediate layer 3 is one of the electrooptical structures shown in fig. 1a, 1b and 1c.

In still another variant embodiment of the invention, presented in fig. 3, between the intermediate layer 3 and the conductive layer 4 there is placed the flexible dielectric layer 15, which is separated from the intermediate layer 3 by means of a flexible additional conductive layer 16. The purpose of the additional conductive layer 16 is to allow for the connection of additional resistance or capacitance elements parallel to the intermediate layer 3 or parallel to the dielectric layer 15. The purpose of the resistance or capacitance elements is the adjustment of the real and imaginary parts of the impedance over those layers, which provides the appropriate division of the D.C. and A.C. voltage components between the layers. In the examplary embodiment of the invention the conductive layer 16 is electrically connected with the conductive layer 4 by means of a resistance element 17. The resistance element, when connected in that way, also reduces the indicator response time after the disconnection of the electric field, when an electrochromic layer, such as the one from fig. 1c, is used as the intermediate layer 3. The dielectric layer 15 can be placed between the intermediate layer 3 and the conductive layer 2, which is not shown in the drawing. In both cases the conductive layers 2 and 4 are connected with each other by means of the diode 5 as in the embodiments described earlier. In this variant embodiment of the invention the intermediate layer 3 is one of the electrooptical structures identical with those shown in fig. 1a, 1b and 1c.

In another embodiment of the indicator according to the invention, the intermediate layer 3, shown in fig. 1b, is a liquid-crystal based structure comprising liquid crystal droplets 11 contained in the pores of a polymer binding material 10. Such structures are known as polymer dispersed liquid crystal structures, abbreviated to PDLC. To build the exemplary embodiment of the invention in experimental conditions, a Polyvision™ membrane produced by Polytronix Incorporated can be used. In the exemplary embodiment of the invention shown in fig. 1, using the PDLC structure in the experimental embodiment of the indicator according to the invention, the conductive layer 4 is provided with a printed pattern, not shown in the drawing, on the side neighbouring the intermediate layer 3, and the conductive layer 2 is transparent across its whole surface. When the indicator is placed in an electric field of a value exceeding the threshold value, the intermediate layer 3 becomes transparent and shows the pattern printed on the conductive layer 4. When the electric field is switched off, the intermediate layer of indicator 3 returns to the light-diffusing state and the surface of the indicator becomes homogenous. The intermediate layer 3 can also be another electrooptical structure, for instance one of known structures based on nematic or ferroelectric liquid crystals.

In still another embodiment of the indicator according to the invention, depicted in fig. 1c, the intermediate layer 3 is an electrochromic structure. In the exemplary embodiment, such structure consists of an electrochromic layer 12 containing an electrochromic compound, electrolyte 13 in liquid or solid form and a layer of ion accumulator 14. If electrolyte in liquid form is used, the intermediate layer 3 is a closed vessel. In the experimental embodiment of the indicator according to the invention the electrochromic layer 14 can be made of tungstic trioxide WO_3, the ion accumulator layer 14 can be made of iridium oxide IrO_x, and the electrolyte 13 can be a solution of lithium perchlorate $LiClO_4$ in propylene carbonate (PC).

In another variant embodiment of the invention, which is presented in fig. 2, there is a flexible dielectric layer 15, placed between the intermediate layer 3 and the conductive layer 4. The function of that layer is to reduce the electric capacitance and to increase the imaginary part of the impedance between the

The intermediate layer of the indicator in this variant of the invention can also be a liquid-crystal based electrooptical structure.

The intermediate layer of the indicator in this variant of the invention can also be an electrochromic structure.

The advantage of the passive voltage indicator according to the invention is its simple structure. The voltage indicator does not require neither its own power source nor a galvanic connection to the source of the tested voltage. Indication is based only on the sensitivity to the electric field present in the direct vicinity of conductors and equipment under voltage, and its reading can be taken by unaided eye from a safe distance. This allows the person taking the reading to avoid contact with such conductors or equipment. It also allows to eliminate insulation elements in the indicator structure. The use of a diode or diodes causes that the indicator's sensitivity to the D.C. component of an electric field can be much lower than its sensitivity to the A.C. component of that field, which makes the indicator readings independent from static charges, which often collect on the surface of live medium and high voltage conductors and equipment, and is very useful when the indicator is applied to power equipment operating under A.C. voltage.

Exemplary embodiment of the subject of the invention is presented in the drawings, in which fig. 1 shows the first variant embodiment of the passive indicator in axonometric projection, figs.: 1a, 1b, 1c – a fragment of the intermediate layer of the indicator in various versions of embodiment, fig. 2 - the second variant embodiment of the indicator, with the dielectric layer, in cross-section, fig. 3 – the third variant embodiment of the indicator, with the additional conductive layer, in cross-section, fig. 4 – the fourth variant embodiment of the indicator in axonometric projection, wherein the non-transparent conductive layer is divided into smaller conductive surfaces, fig.5 – the fifth variant embodiment of the indicator, in axonometric projection, wherein the transparent layer is divided into smaller conductive surfaces, fig.6 – the sixth variant embodiment of the invention, wherein both conductive layers are divided into smaller conductive surfaces, and fig. 7 – an example of a practical application of the indicator.

It is a further object of the invention to provide a passive indicator of voltage presence having a form of a multilayer plate comprising two electrically conductive layers and an intermediate layer of a structure showing electrooptical properties, located between them, wherein the intermediate layer is a display element of the indicator, and the conductive layers are electrodes of the display element, and they are electrically connected with each other by means of a diode, and between the intermediate layer and one of the conductive layers there is located a dielectric layer, which is separated from the intermediate layer by an additional electrically conductive layer, and one of the conductive layers is at least partially transparent.

In the presented three variants of the invention, the intermediate layer of the indicator is preferably an electrophoretic structure.

In the presented three variants of the invention, the intermediate layer of the indicator can also be a liquid-crystal based electrooptical structure.

In the presented three variants of the invention, the intermediate layer of the indicator can also be an electrochromic structure.

It is still further object of the invention, to provide a passive indicator of voltage presence having a form of a multilayer plate comprising two electrically conductive layers and an intermediate layer of a structure showing electrooptical properties, located between them, wherein the intermediate layer is a display element of the indicator, and the conductive layers are electrodes of the display element and at least one of the electrically conductive layers is divided into smaller conductive surfaces, separated from each other and being not in contact with one another, which adhere to the intermediate layer and are electrically connected with the other electrically conductive layer, or with the individual conductive surfaces that other electrically conductive layer is divided into, by means of diodes whose electrodes are oriented in opposite directions with respect to the connected electrically conductive layers or their conductive surfaces, and at least one of the conductive surfaces is at least partially transparent.

Preferably, the intermediate layer of the indicator in this variant of the invention is an electrophoretic structure.

on the polarisation of the applied voltage, causes that the particles of a specific colour move to the surface of the microcapsule, which results in a noticeable colour change of the display.

The practical use of electrophoretic displays as battery charging indicators is known. For instance, from US patent description No. 6 118 426 there is known a battery indicator comprising an electrophoretic display, the first and the second electrode adherent to the display, a non-linear electrical element, preferably comprising a diode, conducting the battery voltage to the first electrode when the battery voltage exceeds a predefined threshold value, a voltage divider electrically connected to the battery and to the second electrode, and a resistor connected with the non-linear electrical element. Voltage from the battery, supplied by the non-linear electrical element to the first electrode, in conjunction with voltage from the battery passing through the voltage divider, is supplied to the second electrode and generates the electric field sufficient to activate the display. When the voltage drops below the threshold value, the potential from the first electrode is carried away through the resistor, which results in a change in the polarisation of the electric field in the display and a change in its appearance.

It is an object of the present invention to provide a passive indicator of voltage presence having a form of a multilayer plate comprising two electrically conductive layers and an intermediate layer of a structure showing electrooptical properties, located between them, wherein the intermediate layer is a display element of the indicator, and the conductive layers are electrodes of the display element and they are electrically connected with each other by means of a diode and one of the conductive layers is at least partially transparent.

It is another object of the invention to provide a passive indicator of voltage presence having a form of a multilayer plate comprising two electrically conductive layers and an intermediate layer of a structure showing electrooptical properties, located between them, wherein the intermediate layer is a display element of the indicator, the conductive layers are electrodes of the display element, and they are electrically connected with each other by means of a diode, and there is a dielectric layer located between the intermediate layer and one of the conductive layers , and one of the conductive layers is at least partially transparent.

Passive indicator of voltage presence

The subject of the invention is a passive indicator of voltage presence, used to indicate voltage presence in electric conductors, high, medium and low-voltage electrically powered devices, electricity distribution systems and electric power transmission lines, especially those operating under high and medium, alternating current (A.C.) voltage. A clear optical signal, which indicates the presence of electric voltage, is generated in the display element of the indicator of voltage presence when the indicator is placed in an electric field generated by electric voltage present in the examined conductor or equipment component.

From published Japanese patent application No. 61-003069 there is known a display detecting live conductors. That device is intended to detect electric field intensity near live conductors by using the threshold voltage of a liquid crystal display. A known liquid crystal display (LCD) with two electrodes and a liquid crystal element is provided with two additional electrodes, of which one is attached to the front surface of the display, and the other to its back surface, the back surface electrode being the one which is placed on the surface of the object which is tested for the presence of an electric field in its near vicinity. Both electrodes of the display are electrically connected with the additional electrodes so that each additional electrode is connected to a different electrode of the LCD. Owing to the additional electrodes, the potential difference generated by the electric field of the tested object between the two electrodes of the liquid crystal element of the display exceeds the threshold value of the display. Always when the examined object is live, the liquid crystal element properly indicates the presence of voltage, which is observed through the display window.